

To: Dr. D. Mills
Director of Research



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**AN INTEGRATED COMPUTING
ENVIRONMENT (I.C.E.)
FOR RESEARCH DIVISION**

Report No 87-279-K

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I.C.E. Planning Project Team

ABSTRACT

This report presents strategies and recommendations for a reference system architecture and implementation plan for an integrated computing environment at Research Division. Such an environment is intended to enhance the capabilities of researchers and to facilitate the overall administrative effectiveness of the Division. Immediate implementation of the plan is recommended such that a useful system is available within 2 years. The plan addresses five key areas: coordinated strategic planning; education, training and support; communications and shared facilities; generic engineering/scientific applications; and generic administrative support applications. Significant value-added benefits are expected, as are benefits in the areas of cost avoidance and cost reduction.

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EXECUTIVE SUMMARY

The I.C.E. Planning Project Team has developed a set of recommendations for a reference system architecture and implementation plan which will, if approved, establish and maintain an integrated computing environment (I.C.E.) for the Research Division. Such an environment is intended to enhance the capabilities of researchers and to facilitate the overall administrative effectiveness of the Division.

We recommend the immediate implementation of an I.C.E. to realize benefits from opportunities that technology currently presents to us. The project should be conducted such that a useful system will be available within two years after the beginning of implementation.

In view of the current budgetary restraint, we designed a "barebone" implementation plan which will still maintain its cost-effectiveness. Our recommended plan encompasses the following five key areas:

1. Coordinated Strategic Planning

- a) Strategic planning for the I.C.E. should continue under the direction of the Manager, Divisional Services Department.
- b) A Technical Computing Support (TECS) group should be established, consisting of researchers and external consultants who are actively using computing technology in areas of interest to other researchers.
- c) Users of the I.C.E. should be the driving force guiding its evolution.

2. Education, Training and Support

- a) Education, training and consultation services on technology in general and common I.C.E. elements in particular should be developed and provided on an on-going basis.
- b) A small group of dedicated staff should be established to support the Divisional network and shared facilities.
- c) Training of staff affected by technological change should be given a high priority.

3. Communications and Shared Facilities

- a) A communications system should be established, consisting of a high-speed network, voice messaging, gateways to other networks/computers, and a modem pool, which will allow access from home/office/lab/field locations.
- b) Basic communications functions should be provided, such as electronic messaging, file transfer, and bulletin boards.
- c) Commonly used hardware, software and services (e.g. document preparation) should be established and maintained, and made available to staff on a shared basis. Site licensing is recommended where practical.
- d) Industry standards should be adopted to the extent feasible.

4. Generic Engineering/Scientific Applications

- a) Key engineering/scientific hardware and software should be acquired and shared over the network. These would include a mini-computer with a standard operating system, programming languages and mathematical packages.
- b) Generic engineering/scientific applications, such as data acquisition, analysis, and display, etc. should be developed and supported over the network and shared facilities.

5. Generic Administrative Support Applications

- a) Key databases and systems, such as project tracking and budgeting should be developed and/or made easier to use.
- b) Generic administrative support applications should be developed and provided. The use of standard software packages and site licensing is recommended where practical.
- c) Divisional and Corporate information should be made easily accessible to staff in the I.C.E.

The benefits from implementing the I.C.E. include:

- (a) value-added, from enhancing researchers' capabilities to produce more timely, innovative and cost-effective research results;
- (b) cost reduction, from a more streamlined and efficient work flow; and
- (c) cost avoidance, from sharing and better utilization of computing resources.

In conclusion, an integrated computing environment has a great deal to offer the Research Division as we attempt to make better use of existing and emerging technologies to become a "centre of innovation." In the words of the Corporate vision:

"We strive for excellence in service to our customers through the talents and commitments of our people and the use of modern technology and practices."

ACKNOWLEDGEMENTS

The I.C.E. Planning Project Team was provided with a great deal of assistance from others within Research Division, elsewhere in Ontario Hydro, and external organizations such as IREQ, SRI and a number of vendors. Over 100 Research Division staff participated in the information-gathering interviews as did the Director and Managers. Information Services Division provided consultants on all three committees. A number of vendors made technical presentations in-house and/or welcomed I.C.E. members to on-site visits and demonstrations.

The Steering Committee in particular was helpful in guiding the overall direction of the project. We would also like to acknowledge the valuable work by the Advisory Committee and Technical Committee in providing specific feedback and suggestions on strategies, the reference system architecture and implementation plan. Members of these three committees are identified in Appendix A to this report.

I.C.E. Planning Project Team

Archie Chung	- Project Leader
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I. C. E. R E P O R T

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Appendix A: I.C.E. Planning Project Organization

Appendix B: Vision

1. INTRODUCTION

1.1 Purpose

The purpose of this report¹ is to communicate to the Research Executive the results of our planning for an Integrated Computing Environment (I.C.E.) for the Research Division. An I.C.E. at the Research Division is designed to provide opportunities for:

- enhancing the staff's research capabilities; and
- improving the Division's administrative effectiveness.

1.2 Current Environment

Research Division:

Currently, Research staff use a diversity of computer technologies to perform a variety of tasks. The level of computer literacy and belief in the value of computers varies considerably within the Division. Technical support is provided by local experts and by the Computer Support Unit (CSU) of the Operations Research Section. Apart from a small number of terminals and personal computers (PCs) maintained by the CSU, there is little sharing of local hardware, software, data or expertise beyond local work groups.

There have been problems justifying the cost of required facilities and evaluating acquisition decisions. Other problems include slow or inadequate communications, incompatible equipment and sizable time spent by staff in overcoming computer problems.

Each Section plans and manages its own computer resources and in 1987, estimated costs for acquiring computer-related facilities is around \$2M (about 4% of our gross expenditures). **The demand for computer facilities and services is expected to increase for the next 3 years.** However, the capital and OM&A funds available to the Division are expected to be limited.

¹ This report is one of the three deliverables of the I.C.E. Planning Project. The other two are: a) a series of support documents which give detailed information on the key elements contained in this report; and b) a report documenting our experience in this project for the benefit of future strategic planning processes.

Ontario Hydro:

A similar situation exists in almost every part of Hydro. Faced with limited resources and the need for sizable investments in computing resources, many divisions are taking initiatives to coordinate technology planning and to look for ways to better utilize computer resources.

In the area of data communications, College Park has installed a local area network with a fibre optic link to H.O. and the Atrium. A high speed fibre optic link from Kipling site via Manby to H.O. is being installed and will be functional in 1988. Facility Management Services (FMS) is working on a data cabling plan for the Kipling site. A plan for corporate-wide coordinated data communications is being investigated by Information Services Division (ISD), FMS and Telecommunications Department.

Other Research Institutes:

Of the research institutes that we contacted or visited, SRI, IREQ and IBM's Watson Labs have had integrated computing environments for years. Others are either planning for one or are in the process of installing one.

1.3 Environmental Predictions

Our society is moving into an *information economy*--more people will be performing information-related activities; more money will be spent on computer and communications facilities and services; and a global restructuring of work patterns will continue, moving us from an industrial to an information society. A synopsis of our predictions for the next 5 years is given below:

People -

- People will be better informed and positioned to use computing and communications resources.
- The use of computers will not be justified on the basis of cost savings alone. The "value added" concept will be widely recognized.

Technology -

- The power and performance/price ratio for computer and communications technology will double at least every 2 years.
- At the low end, powerful, high performance, and multi-tasking workstations will replace PCs for engineering and scientific work.

- At the high end, supercomputers, vector processors and mainframes will show dramatic gains in performance/price ratios.
- Software will become more powerful and much easier to use and will be available in a wide range of areas at affordable costs.
- User-interfaces with graphics, pointing devices, and voice recognition will supplement keyboards.
- Standards will continue to be a focus but the emergence of standards will be slow.
- Cooperative computing with products from various vendors will become the norm. Pressured by the users, major vendors will incorporate standard interfaces.

Applications -

- Use of computers will evolve from "data processing" to "intelligent" uses for augmentation of human capabilities.
- Local workstations will play a major role in the collection, analysis and reporting of engineering/scientific data, and their use will increase.
- Large scale, real time simulations will become an economic alternative to experiments and testing using physical models.
- Voice interface, being a hands-free device, will have great impact on laboratory and field work.
- Powerful microcomputers will be widely used to design and control sophisticated, complex experiments and field tests.

Information -

- Integration of information (text, data, voice, image and video) in electronic or optical forms will dramatically improve information storage and exchange.
- More and detailed data will be gathered, reduced, stored and used; access to this information will be essential for research projects.

Resource Management -

- Reliance on expert technical support will grow.
- Dedicated planning, coordination, and management of technology resources will be a major part of business operations.

Economics -

- Although the "unit cost" for computer hardware and software will decrease rapidly, the total cost of computerization in the Research Division will increase due to new and increased use.
- Even though there are time and money savings from efficiency improvements, the prime benefit of computerization will be the ability to do new things that would enhance the effectiveness of Research Division (value-added benefits).

1.4 Scope of the Project

Given the above environment, we need to answer the following question:

How can Research Division take advantage of the emerging technology to enhance researchers' capability, improve administrative effectiveness, and in the long run, gain a competitive edge in a technologically volatile and financially restrained environment?

Approaches to seek answers to this question are varied and complex. Answers to this question are also dynamic and vary with organizational climate.

However, one thing is certain: with adequate *planning and coordination*, Research Division staff will be able to assess a broad spectrum of facilities, information, and expertise; and to better collaborate with peers and clients both within and outside of the Research Division.

The I.C.E. Planning Project approach was to address the above question at the **strategic level**, i.e., to plan for the **general computing capabilities** for the Division. It is *not* intended to provide a universal solution to all Research Division computing needs; *nor* will it provide a detailed system design for the general computing environment at the Division.

The approach we took to develop Research Division's computing strategies was through the formation of a "vision": *a desired state of the computing environment in the Research Division*. This vision is based on

an understanding of requirements (*anticipated "needs and wants" both at the individual and the divisional levels*) and the current and predicted future environments.

2. REQUIREMENTS

In general, there is a wish for the Research Division to become a *centre of innovation*. To this end, there is a growing need to provide better computer support for individual researchers, to reduce overhead, to increase competitiveness, and to focus management attention on the expansion and better use of computing resources.

A synopsis of requirements is given below:

People -

The most important and urgent requirements are in areas such as:

- training in effective use of computers;
- education in general and specialized topics;
- consultation on suitable facilities to acquire or use;
- advise on state-of-the-art development and alternative computing methods;
- debugging of hardware and software; and
- development of computer systems and programs.

Applications -

The four major areas are:

- communications with external clients, peers, and field instruments;
- statistics, computer modelling and simulations, engineering graphics;
- preparation and production of high quality technical documents with integrated text, data, colour graphics and image; and
- administrative support such as project tracking, budget preparation and divisional databases.

Others include:

- messaging, information exchange, bulletin board and conferencing;
- information management;
- data acquisition and experiment control;

- specialized applications such as Finite Element Analysis and Power System Reliability; and
- advanced applications such as Artificial Intelligence and visual interactive modelling and simulations.

All facilities must be available around the clock and accessible from remote locations.

Information -

Timely and easy access is needed to corporate databases, external libraries, commercial networks/bulletin boards, and Divisional databases such as project tracking, budget and inventories of expertise and facilities.

Technology -

A diversity of technologies is needed to support the variety of tasks performed in the Division. The technologies used for the shared facilities within the Division must be flexible to accommodate future expansion and be compatible with the diversity of local facilities to the extent possible.

Resource Management -

The use of shared facilities should be optimized with maximum convenience for the users and minimum cost to the Division. Use of external resources (hardware, software, data and expertise) should be considered before acquiring our own resources. The cost of shared facilities should be distributed fairly with minimal administrative burden.

3. VISION

A synopsis of the vision is given below. Appendix B gives a narrative version of the vision from staff's perspective.

People -

The staff of the Division (researchers, support personnel, administrators and managers alike) are aware of, feel comfortable with, and appreciate emerging technologies. Innovative use of these technologies to produce new and better research products is a way of life. Work patterns and organization structure evolve to better utilize these technologies. Cooperation and sharing of hardware, software, data and expertise are

parts of the Division's culture. Staff of the Division:

- are more productive in performing existing activities;
- produce better results by doing existing tasks differently; and
- produce innovative results in new areas.

Applications -

High performance workstations capable of multi-tasking involving voice, data, text, colour image, and full motion video are available at the workplace (office, lab, field, home or other remote locations) with a *single* user interface that can be tailored to both novice and experienced users with access to local resources and powerful computers around the globe.

Information -

The following information is timely, and easily accessible by staff:

- all Divisional and external information and library resources;
- facilities to identify information sources easily;
- software to select relevant information from information sources;
- services for selective dissemination of information; and
- facilities to query experts' knowledge and experience.

Technology -

Behind the stable user interface is a powerful system which is evolving and open to change as new technologies become viable (flexible). It is capable of performing a variety of functions (versatile) and accommodates a diversity of local computer hardware and software needed in the Division to the extent possible (compatible). The system is available around the clock and from anywhere in the globe (accessible); can accommodate changes smoothly (stable); has minimum down time (reliable); has controlled access to software and data (private); with minimum damage to software and data (secure).

Resource Management -

There is an on-going, user-driven, integrated planning and budgeting mechanism for shared facilities and services in response to research priorities, budgetary climate, and users' needs. A small, competent group of dedicated staff manages the shared facilities and applications. Local, specialized applications are supported by dedicated staff, through cooperation among staff or self-reliance. The best affordable hardware and software are provided. Sharing of resources (hardware, software, information and expertise) is facilitated through Divisional facilities and hardware/software pools.

4. I.C.E. STRATEGIES

Our vision, in conjunction with current and predicted future environments is used to derive a set of I.C.E. strategies that can be used to guide the development of I.C.E.. Our basic strategy is *to enhance communications, resources utilization (through sharing and standards), and staff support*. A synopsis of the strategies is given below:

People Strategies -

- To establish a planned and on-going **education/training program** in areas of existing computer resources and technology trends to maintain an appreciation of technology and appropriate staff skills in the effective use of computer resources.
- To create and maintain a competent **technical support group** of researchers for promoting and facilitating self-reliance and cooperative support within the Division.
- To create and maintain a **Division-wide program** for monitoring and assessing the impacts of computer technology on work patterns; to re-organize work units and modes of operations; and to re-train/re-deploy staff when justified.

Applications Strategies -

- To develop and maintain a stable, uniform, and easy-to-use **user interface** for accessing multiple computing and data resources; and to facilitate local specialized applications with the same interface tailored to the needs of both novice and experienced users.
- To develop and maintain (recognizing the diversity of local applications within the Division) a set of **hardware and software standards** to

support common applications such as document preparation, presentation graphics, spreadsheet, data management, statistics, data acquisition and experimental control.

- To monitor and introduce **new and beneficial applications** as they become viable.

Information Management Strategies -

- To promote the **sharing, exploration and utilization** of divisional and external information resources.
- To facilitate easy and convenient access to information sources.

Technology Strategies -

- To establish and maintain a high performance **communications network** and **shared facilities** with **proven, evolving and open-ended** technologies for facilitating global communications and the sharing of computing and information resources.
- To adhere to national and international **technology standards** for hardware and software in concert with the diversity of technologies required by the Division.
- To utilize all proven technologies as appropriate; and to make a **smooth transition** to new technologies as they become viable.

Resource Management Strategies -

- To address explicitly the **Divisional computer facilities** in the Division's business plan.
- To make the **budgeting** of I.C.E. a part of the normal Divisional budgeting process.
- To make the **users** of the I.C.E. the prime driving force governing the evolution of I.C.E..
- To create a **dedicated group** to operate and maintain the shared facilities, to deliver expert support to shared applications, and to provide consultation to local, specialized needs.
- To **distribute costs** for shared facilities and services by annual allocations of budgets by department and by forecasted usage.
- To encourage and facilitate the use of **external resources** (hardware, software, information, services and expertise) whenever appropriate.
- To continue the practice of **local planning** for local, specialized hardware and software; and to actively promote and facilitate the sharing of local computer facilities.

- To build I.C.E. from the existing base of hardware, software, staff knowledge and skills.

5. REFERENCE SYSTEM ARCHITECTURE

The reference system architecture is a high-level plan that addresses the key elements and characteristics of the system including physical components (communications equipment, computer hardware, peripheral devices, etc.), software, data, standards, organization and service objectives. The basic concept of our system architecture is to add a divisional layer consisting of a communications network, shared facilities and services to the existing base of local, specialized facilities in order to enhance their capabilities.

The I.C.E. system will be based on the concept of a hybrid network. Computing equipment will be distributed, with local resources meeting local requirements and central, shared equipment providing capabilities that are too expensive to duplicate. Integration across the system is provided by a high-speed communications network, by common standards and by a central support group.

5.1 Technology

Figure 5.1 is a schematic view of the physical components of I.C.E., including:

- a variety of *workstation* devices located at the user's desk, laboratory, field site or home;
- a *high-speed network* linking these devices together and to shared services;
- a *communications link* with Head Office and a modem pool for communications through the telephone system; and
- *shared equipment* including computers, data storage disks and input/output devices.

Workstations: Personal computers and advanced engineering workstations will serve as the main tool for communications and for many engineering, Figure 6.1

scientific and administrative applications. They also provide a point of entry into the full I.C.E. system.

*Network:*² A high-speed local communications backbone will join all Research Division buildings on the Kipling site and link any lab or office where a need exists. Connections to individual workstations may be directly to the backbone, or via local area network cabling within a building, lab or office.

Communications Link: A high speed connection with Head Office facilities will be provided. Other locations (homes, field sites and other cities) will be reached via a modem pool connected to Bell telephone lines. A voice messaging system³ is recommended to improve person-to-person communications.

Shared Computing Resources: Divisional level equipment/services would include⁴:

- central computer(s) to support network management, shared applications and databases and to act as "file servers." Divisional computers would also function as "compute servers" on the network, running jobs too large for local workstations.
- high performance output devices including high volume laser printers, plotters and colour graphics output devices.
- image scanners to "read" text and graphics into computer databases.

The I.C.E. network will also provide easy and high-speed access to mainframe computers and databases located throughout the Corporation⁵

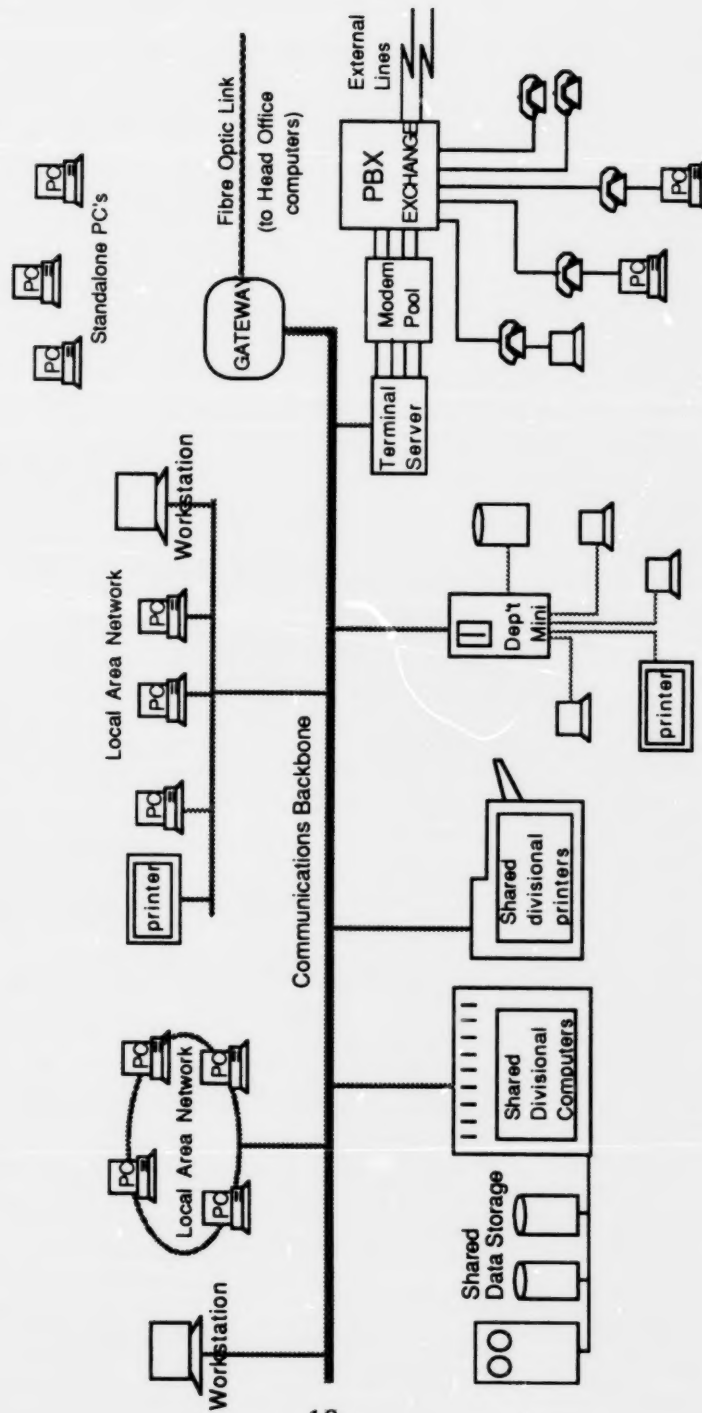
² Other communications needs (e.g. integrated voice, video and data) may be served by an integrated communications system in the future. Technology to deliver these services economically does not exist at present.

³ This centralized messaging system would be integrated with the telephone system.

⁴ Equipment and services should be added to the system as needs develop, technology emerges and resources become available. Responsibility for development of the system will lie with the Technical Computing Support group (TECS) described in Section 5.4.

⁵ The Information Services Division is considering a satellite site, backing up the Orde Street computer centre, on the Kipling site. This would give Research Division staff convenient access to powerful computing resources. However, the satellite site has not been committed yet.

Figure 5.1: ICE Hardware Architecture



and to external resources like the University of Toronto Craysupercomputer. Commercial time-sharing services will be accessed through telephone connections.

5.2 Applications

The term "applications" is used to refer to the work done with computers and the software that gets it done. Depending on the applications, the software may be for local workstations or for central computers. *Site licenses* allowing many users to share software will be obtained where practical. The following applications will be supported within I.C.E.:

Communications -

- messaging and electronic mail;
- file transfer between similar or dissimilar computers;
- bulletin boards and conferences⁶;
- gateways to external network services⁷ and to online databases for scientific or economic information.

Generic Engineering and Scientific Support -

- system software and programming languages;
- data acquisition software and instrument support packages;
- statistical packages for data analysis;
- graphics packages for data display and high-quality output;
- mathematical subroutine libraries;
- computer-aided design and drafting (CADD);
- library resources, including: the Corporate On-line Public Access Catalogue, a periodicals catalogue, and external on-line databases.

Administrative Support Applications -

- project tracking: The interface to and capabilities of the present project tracking system will be substantially improved.

⁶ These are computerized user forums that will be used to spread news or post requests for information on a particular topic.

⁷ External services include BitNet, NetNorth, Telex, Envoy 100, etc.

- budget preparation tools (computerized spreadsheets and forms) will be distributed via I.C.E. This will make the preparation of the budget more consistent across the Division and simplify consolidation of section and department budgets into the Divisional budget.
- administrative data: telephone directories, and Research Division Instructions (RDI) etc. will be accessible via an on-line database.
- administrative services such as conference room booking, equipment inventories and stock room accounting support will be provided.

Document Preparation -

I.C.E. will support the production of documents, drawings, publications and slides. Standards will be adopted to simplify co-authorship and improve the level of support that can be offered by the Divisional word processing and drafting centres. Applications will include:

- word processing;
- translators to convert files produced by popular word processing packages;
- desktop publishing - for the production of documents with integrated text and graphics;
- professional grade document preparation for annual reports and promotional literature; and
- presentation graphics - for reports, slides, etc.

5.3 Information

The I.C.E. system will make a variety of information easily accessible to the Division's staff. Divisional information will be organized through the I.C.E. system, while Corporate and external sources would be accessed through ISD or other agencies. Examples include:

- Divisional Information Resources such as: project tracking; budget and accounting data; PRF registry; administrative information like RDI, policy manual, file system index; skill and expertise inventory; staff profiles; a registry of courses and training material, supplied by the Human Resources Branch; and a database containing abstracts of all Research Division reports.
- Corporate Information, including: telephone directories; MMR data; drawing registers; and specialist technical databases such as system operating statistics, OH-BEEF (Biological Effects of Electromagnetic Fields) and boiler tube records.

5.4 Services and Support Structure

The proposed support structure is characterized by integrated planning and budgeting, coordinated operations, user-driven planning and cooperative support.

We recommend that two new groups be established. Responsibilities for these groups are summarized in Table 5.1.

- The I.C.E. support group (ISG) will be a new unit of five people working full-time on I.C.E. operations and support. This unit will report to the Manager of the Divisional Services Department. It will be responsible for installing, operating and maintaining equipment, arranging training and education and providing a consulting service (including a "hot-line") for staff using I.C.E. facilities.
- The TECS (Technical Computing Support) group will consist of approximately twelve researchers and external specialists with interests and expertise in application areas that are important to the Research Division. These individuals will work part-time on I.C.E. The TECS group will monitor user requirements and technological developments and advise management on strategic planning for the I.C.E. system. They will be responsible for managing widely used engineering/scientific and administrative applications, providing expert consultation to the Division's computer users and arranging education programmes that will help researchers become more effective users of the tools that I.C.E. makes available.

We anticipate that many services (library, equipment installation and maintenance, applications development, training etc) will be acquired from outside contractors or other Hydro divisions, such as FMS and ISD.

5.5 People

- Education and training requirements on PC's, other current systems, and state-of-the art technologies will be identified and addressed.
- Training will be provided in the use of basic I.C.E. services such as the communications network and divisional administrative applications.
- Training of staff affected by technological change will be a high priority. Service jobs should be enriched as routine tasks are

Table 5.1 Responsibility Chart for ICE Management, Support and Training Functions

TASK	WHO IS RESPONSIBLE FOR THE TASK?	WHO IS RESPONSIBLE FOR DOING THE TASK?	WHO SHOULD BE CONSULTED?	WHO MUST APPROVE?
1. Strategic planning for I.C.E. Network, shared facilities, and support "...	Manager-DSD	ISG, TECS	LIB, EXT	REX
2. Management of the I.C.E. Network & shared facilities	Manager-DSD	ISG	TECS, LIB	REX
- operations planning and budgeting	ISG	ISG, EXT	TECS, LIB	LINE
- acquisition/development, installation & testing	ISG	ISG, EXT		
- operation and maintenance	ISG	ISG, PERS, LIB, EXT	TECS	
- formal training (skills)	ISG	ISG		
- consultation ("hot line")	ISG, TECS	ISG, PERS, TECS, LIB, EXT		
- education (awareness and knowledge)				
3. Management of generic applications: ...	TECS	ISG, CSU, EXT		LINE
- engineering/scientific	TECS	ISG, DSD, EXT		LINE
- administrative support	Local Line Mgmt	Local staff, CSU, EXT		Local Line Management
4. Develop/acquire and support local and specialized hardware, software and applications				

facilities include hardware, system software (excludes generic eng/sci & admin applications)
 includes identification; recommendation of standards
 covers functions itemized in #2

DSD - Divisional Services Department
 ISG - ICE Support Group
 TECS - group of RD users "expert" in major application areas, including admin support
 LIB - OH/RD Library
 CSU - Computing Support Unit

PERS - Personnel
 EXT - External staff, such as ISD, FMS, consultants, vendors, etc.
 LINE - Mgr, DSD and higher as required
 REX - Research Executive Committee

computerized. (E.g. Desktop publishing will replace routine typing and drafting. Databases will supplement traditional files.)

5.6 Standards

The concept of an Integrated Computing Environment requires coordination of the Research Division's computing resources and a commitment to sharing and communication. To make this work effectively, it is necessary to develop and maintain standards for the use of computers and communications equipment. By adhering to the I.C.E. standards, the user will get help and convenient access to shared facilities. Non-standard equipment or systems may be connected to I.C.E., but responsibility for support would rest with the user.

The following standards are proposed by the I.C.E. Technical Committee⁸:

Hardware Standards -

- Communications hardware will be compatible with the IEEE 802.3 standard using "Ethernet" baseband cable.
- The popular IBM PC provides a de-facto standard for small desktop systems. Support for PC's, compatibles and PC applications should be part of I.C.E. Support for other PC-scale machines (especially Apple MacIntosh) will be provided where interest and numbers warrant.

Software Standards -

- Communications standards will eventually be based on the ISO Open System Interconnect (OSI) model. However, as these standards are not completely defined, we propose TCP/IP and NFS (Network File System) protocols as interim standards.
- Central (divisional) computers will be coordinated through software standards. We recommend UNIX as the standard multi-user, multi-tasking operating system for engineering workstations. "Proprietary" operating systems⁹ will be allowed for existing equipment.

⁸ With the implementation of the project, the responsibility for developing and maintaining these would shift to the I.C.E. support group and the TECS.

⁹ VMS for VAX machines and VM/CMS for IBM.

- MS/DOS is a de-facto standard for PC's and must be supported under I.C.E. OS/2 is likely to emerge as an important standard for "high end" PC's.

Data Standards -

- SQL (Structured Query Language) should be the standard interface approach for large shared databases.

5.7 COST ESTIMATES

A very preliminary estimate of the minimal cost option for I.C.E. is as follows:

Shared Facilities:

- Voice Messaging System	\$250,000
- Network Cabling (including 100 "initial" user connections)	950,000
- Gateways and H/O connection	150,000
- Central Computers (10 GB storage)	650,000
- High-volume laser printer, scanner, plotters	150,000
- Systems and Applications Software	<u>500,000</u>
	\$2,650,000

Departmental/Section Facilities¹⁰

- Network connections/user (hardware and software)	\$1,250
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Recurring Costs (annual):

- Full-time support staff	\$300,000
- Equipment/software service contracts	<u>150,000</u>
	\$450,000

¹⁰ Budgeting for terminals, workstations and small computers will remain the responsibility of the departments/sections that use them.

6. RECOMMENDED IMPLEMENTATION PLAN

Recognizing the very limited resources available for 1988 and 1989, we have developed an implementation strategy governing the scope, timing and speed of implementation.

In view of the budgetary restraint, we designed a "barebone" implementation plan which will still maintain its cost-effectiveness. We recommend that the implementation begin immediately since current technology provides opportunities for us to benefit now. The penalty of not implementing now is that we will be forced to spend more for far less benefits over the next 2 to 5 years. Once we begin implementation, we must establish a useful I.C.E. within two years or there will be a very high risk of rejection by our users, which will make the I.C.E. implementation ineffective.

The implementation plan has also been developed in accordance with the strategy of bottom-up implementation, to maximize benefits at the user's level as soon as possible. To do this, there are two critical elements that precede all others:

- a) a basic communications capabilities must be provided, together with key applications, as quickly as possible;
- b) an initial "critical mass" of staff must be provided with access capabilities and training. About 100 hook-ups are planned for the initial population.

Some experiments with communications options are currently underway in Research Division¹¹. Based on these experiences and others in Ontario Hydro, we expect to begin the first specification stage in November. Maximum reliance will be placed on the use of external resources to supplement those available within the Division. These will taper off in 1989 as internal staff is hired and the major implementation work is finished. Table 5.1 in the preceding section identifies the responsibilities assigned to various stakeholders.

In brief, the following activities are planned for completion in the indicated time frame:

¹¹ A baseband Ethernet is being installed in KB, and Chemical Research is doing a pilot using SL-1.

	<u>Completed</u>
6.1 <u>Continue a Coordinated Strategic Planning Process</u>	
1. Designate the Manager, Divisional Services as being responsible for strategic planning of Divisional computing.	Q4, 1987
2. Appoint members of the TECS Committee. ¹²	Q4, 1987
6.2 <u>Establish On-going Education, Training Support Program</u>	
1. Acquire a temporary resource to develop and conduct education and training programs for communications and generic applications (required until mid-1989).	Q1, 1988
2. Establish and staff on-going education and training service function at Research Division, involving both the Library and Personnel.	Q4, 1988
6.3. <u>Establish the Communications Backbone</u>	
1. Appoint 2 permanent staff to lead and coordinate.	Q4, 1987
2. Acquire external services. ¹³	Q4, 1987
3. Develop specifications for the network.	Q4, 1987
4. Hire 1 permanent analyst to support the network.	Q2, 1988
5. Acquire and install the backbone. ¹⁴	Q2, 1988
6. Acquire and install the hardware/software for the initial population connections.	Q2, 1988
7. Test the backbone and initial connections.	Q3, 1988
8. Acquire, install and test the basic communications functions. ¹⁵	Q3, 1988
9. Develop and conduct training on basic communications functions for initial population.	Q4, 1988

¹² The time spent by TECS members in total will add up to about 1 labour year (Ref. section 5.4).

¹³ External services will likely be obtained from ISD, FMS, consultants, vendors, etc.

¹⁴ The backbone consists of a high-speed network, modem pool, voice messaging system, etc. (Ref. section 5.1).

¹⁵ Basic functions include electronic messaging, file transfer, bulletin boards, etc. (Ref. section 5.2).

Completed

10. Acquire, install and test the hardware/software, and provide training for other Research Division staff as required. 1989-90

6.4 Implement Generic Engineering/Scientific Applications

1. Develop specifications for key eng/sci hardware and software.¹⁶ Q2, 1988
2. Acquire and install key eng/sci hardware and software. Q4, 1988
3. Develop specifications for other generic eng/sci applications. Q4, 1988
4. Hire 1 permanent analyst to support generic eng/sci applications. Q1, 1989
5. Test key eng/sci hardware and software installation. Q2, 1989
6. Develop and implement generic eng/sci applications. Q2, 1989
7. Develop and conduct training. Q3, 1989

6.5 Implement Generic Administrative Support Applications

1. Hire 1 permanent analyst to support generic administrative support applications. Q1, 1988
2. Develop specifications for key databases/systems.¹⁷ Q1, 1988
3. Develop and implement key databases/systems. Q2, 1988
4. Develop and conduct training on key databases/systems. Q3, 1988
5. Develop specifications for other generic administrative support applications. Q3, 1988
6. Develop and implement them. Q4, 1988
7. Develop and conduct training on them. Q1, 1989

¹⁶ Key facilities are expected to include a mini-computer and UNIX/NFS (Ref. section 5.1).

¹⁷ Key areas are expected to be project tracking and budgeting (Ref. section 5.2).

Figure 6.1 illustrates the recommended schedule for the communications and generic applications tasks. Table 6.1 identifies the expected minimum costs of implementation according to this schedule. Beginning in mid-1988 some of these activities will be conducted on an on-going basis, such as:

1. development/acquisition and delivery of required training, consultation and education;
2. development and support of generic applications;
3. operation and maintenance of the divisional network and shared divisional hardware and software.

RECOMMENDED IMPLEMENTATION SCHEDULE

Figure 6.1

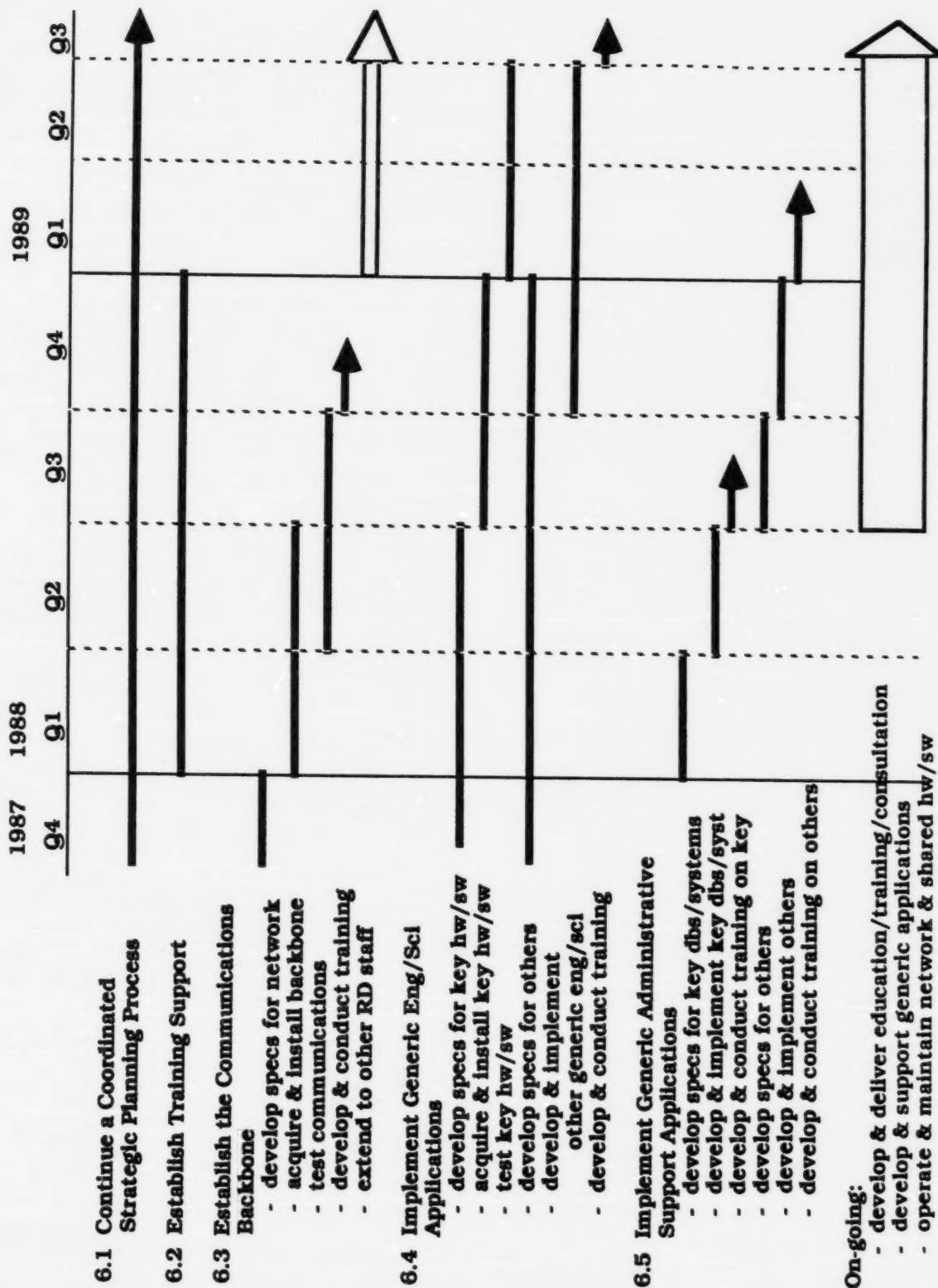


Table 6.1 - Estimated Minimum Costs of Implementation¹⁸

	(\$000)	
	1988	1989
<u>CCP</u>		
Voice messaging system	250	-
Network cabling	<u>800</u>	<u>-</u>
	\$1,050	\$0
<u>Minor Fixed Assets</u>		
Initial 100 network connections	150	-
Gateways and H/O connection	150	-
Central Computers	250	400
High-volume laser printer, scanner, plotters	<u>50</u>	<u>-</u>
	\$600	\$100
<u>OM&A</u>		
Systems and Applications Software	300	200
Full-time support staff	250	300
External resources	250	200
HW/SW service contracts	<u>50</u>	<u>150</u>
	\$850	\$850

¹⁸ The breakdown to CCP, Minor Fixed Assets and OM&A may change with different budgetary assumptions.

7. BENEFITS FROM IMPLEMENTING I.C.E.

With the implementation of I.C.E., a wide range of benefits can be realized. Since people will benefit from I.C.E. in different ways, it is difficult to list all possible benefits, or to agree upon what are the major benefits. However, some common benefits can be stated here with estimated impacts, either cost reduction or capability-enhancement, to the Division.

We loosely grouped these benefits into the following categories:

- (1) **Value-added** - These are the potential benefits describing the strategic, mission-oriented benefits to the Division as a whole. These value-added benefits will enable us to produce timely, innovative and effective research products. Although they are usually realized years later from our clients and Ontario Hydro, which cannot be easily measured or estimated now, they will have the most profound impact on the Division and the Corporation. If converted to dollars, these benefits can amount to several thousands of times the investment we recommend. Some examples include:

- Staff can work whenever and wherever is most convenient and efficient.
- Timely interaction with clients, peers and associates.
- Greater access to and coverage of resources.
- More appropriate hardware and software to choose from and use.
- More time to do research work.
- Can do things that were not economical before.
- Can do new things.
- Better management information for strategic, tactical and operational decision-making.

- (2) **Cost reduction** - These are potential benefits resulting from a more streamlined and efficient work flow. It will result in lower material costs, fewer support requirements and time savings. Some examples are:

Materials - By creating, storing and distributing research reports and memoranda in electronic form, we will reduce the cost of paper and copying, filing cabinets and space, etc.

Support requirements - With electronic mail, mail delivery requirements will be reduced. Messaging will reduce the telephone calls and free-up secretaries' or colleagues' time in making telephone tags. Typing and drafting requirements will also be reduced, allowing typists, secretaries or drafting staff to do other productive work.

Labour time savings - File transfer between dissimilar computer systems will greatly reduce labour hours in printing and re-keying the same information many times.

- (3) **Cost avoidance** - These are the potential benefits from achieving the same or greater capabilities with the same or less expenditures for computing facilities. This category of benefits is usually achieved through sharing and/or re-distribution of expenditures. Some examples are:

Hardware - I.C.E. will provide an opportunity to share computer hardware within and outside of the Division, and to allow expensive equipment to be shared over the network. It is particular important at a time of limited funds.

Software - I.C.E. will provide site licenses for commonly used software and thus will reduce the total expenditure on common software, allowing funds to be used for software needed for local, specialized applications.

Processing - I.C.E. will provide ready and easy access to various computer systems, thus allowing staff to choose the most cost-effective system to use.

8. OUTSTANDING ISSUES

A number of issues that are important to the I.C.E. were not addressed or resolved by the project team because of the lack of time or information. They should be addressed in the on-going planning process. These issues are listed below in order of urgency.

- Responsibilities for data cabling for inter- and intra-Research buildings at Kipling - Key players are Manager of Divisional Services, ISD and FMS.
- Detailed mechanism for integrated budgeting and charge allocations - Key players are Manager of Divisional Services and the Research Executive.
- Responsibilities for establishing connections with corporate and external databases - Key players are I.C.E. Support Group, Library, ISD and custodians of Corporate databases.
- Responsibilities for Division-wide programs for monitoring and assessing impacts of I.C.E.; and for recommending and implementing necessary changes in work pattern, organizational structure, budgetary and space requirements, etc. - Key players are Personnel and the Research Executive.
- Network security issues such as physical, logical (access control), and policies/procedures - Key players are Manager of Divisional Services, TECS, FMS, and ISD.

9. CONCLUSION

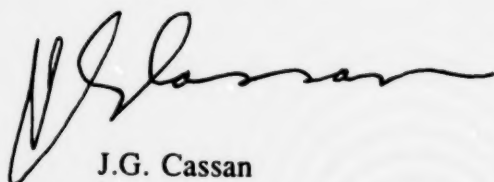
We consider the timely implementation of I.C.E. essential not only for the Division to become a *centre of innovation* but also for the Division's long term effectiveness to serve Ontario Hydro. In addition to the long term cost savings associated with the implementation of I.C.E., there are value-added benefits which will far exceed the benefits derived from pure cost savings. **Timing is important:** we must start implementing now and then proceed with it as fast as economically affordable, building from our existing base and making a fast but smooth transition to our vision of I.C.E..

However, building an effective I.C.E. will take time and a sizable resource investment, and the benefits will usually be expected two to three years after the beginning of implementation. As the Division's staff are the key to realization of the benefits, management's attention to staff education, training, and support is vital to a successful implementation of I.C.E..

The dynamic environment we are in today demands that strategic planning for the I.C.E. be continued. New technologies and applications

such as colour imaging, full motion video, large scale simulation and real time pattern recognition are on the horizon. The I.C.E. architecture we are recommending is capable of making a smooth transition to accommodate these new technologies and applications. A great challenge and responsibility lies ahead for the I.C.E. implementation team, the TECS and everyone in the Division to take full advantage of these opportunities!

Approved:

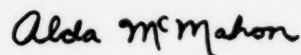


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Manager
Operations Research

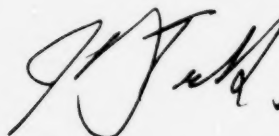
Submitted:



A.H. Chung
I.C.E. Project Leader



A.A. McMahon
I.C.E. Project Coordinator



J.D. Tulk
I.C.E. Technical Chairperson

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Project Coordinator: Alda McMahon
Technical Chairperson: Jim Tulk

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Bruce Brown
Jim Brown
Stan Frost (ISD)
Al Kupcis

Advisory Committee

Mikk Anyas-Weiss
John Baron
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John Jackson
Rick Madge
Angela Mazzonna (ISD)
Stephen Mills (ISD)
Neville Pereira
Mark Vainberg
Mario Vitti (ISD)
Susan Wright

ISD - Information Services Division

VISION

APPENDIX B

Date: June

Place: Ontario Hydro Research Division

With his morning coffee in his hand, Mike Sharpe sat down at his workstation and entered his password. A list of the day's activities was immediately displayed, including some notes he had made to jog his memory. At the touch of a key, messages that had been sent to him since he last checked his mail basket were displayed. One of them was from Claude Cadeau, his collaborator at IREQ, telling him that he'd made some changes to their paper on "Optical Vibration Monitoring". He also asked whether Mike was aware of recent work by Ryder at Brookhaven and asked Mike to contact him as soon as possible.

Mike touched another key to display the paper attached to Claude's message, and quickly scanned the highlighted changes. Another key provided an on-line telephone index, and he placed a call to Ryder. A message appeared on the screen indicating that the line was busy, and that Mike's phone would ring as soon as a connection was made. While he was making some further changes to the document, Ryder called and they discussed the details of their work. It was clear that some important information should be added, and they initiated a linkup of their workstations. Ryder pulled in a "carbon copy" of what appeared on Mike's screen. Both researchers continued to chat about the changes each was keying into the document and before the conversation ended, Mike incorporated a reference document that Ryder had obtained from Brookhaven's library and transmitted.

After hanging up, Mike completed his re-write of the joint paper and sent a brief message to Claude with the revised document. He then logged into the BRUCE computer network and had a look at the pump motor vibration patterns which were being monitored on a continuous basis. He also sent a message to the shift supervisor asking him to shift one of the accelerometers to a different location. Seeing that there were no meetings scheduled for the afternoon, Mike decided to go home for lunch and continue working there.

After lunch, he used his home PC to hook-up into the Division's network and proceeded to develop some overheads for a presentation he had promised his department manager. Mike was able to include the latest test results in the graphs, after connecting briefly with the BRUCE network. At the last minute, he decided to include cost figures for the project to-date

and accessed the divisional accounting database to obtain the information. Mike then directed the material to a laser printer at the lab, knowing that the overheads would be waiting for him when he got into work the next day.

As he finished for the day, he mused over the fact that three years ago he would never have dreamed that he would be collaborating with anyone else, much less with someone in IREQ over 400 miles away. Mike felt very happy that he was not working in a vacuum by himself any more. Since being linked with Claude and others over the networks, he felt much more confident about what he was doing and found that the progress of the work advanced at a much faster rate when information was not "held up in the mail". He also appreciated being able to do his work at times and locations most convenient for him. Exhausting travel, delayed mail and "telephone tag" were things of the past here at the Research Division.

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